II. *Some Thoughts and Experiments Concerning* Vegetation *By* John Woodward, *M. D. of the College of Phyſicians, & R. S. & Profeſſor of Phyſick in* Greſham-College.

THE *Ancients* generally intituled the *Earth* to the Production of the *Animals*, *Vegetables*, and *other Bodies* upon and about it: and for that reaſon 'twas that they gave it ſo frequently the Epithets of *Parent* and *Mother* *. They were of opinion that it furniſhed forth the *Matter* whereof *thoſe Bodies* conſiſt: and received it all back again at their Diſſolution for the Compoſure of *others*. Even thoſe who aſſerted *four Elements*, ſuppoſed that the *Earth* was the *Matter* that *Conſtituted* thoſe Bodies: and that *Water* and the *reſt*, ſerv'd only for the *Conveyance* and *Diſtribution* of that *Matter*, in order to the *forming* and *compoſition* of them. 'Tis true, *Thales*, a Philoſopher of the firſt rank in thoſe early Ages, has been thought to have Sentiments very different from theſe; but that without juſt Grounds; as I think I have ſufficiently proved in another Paper, which I am ready to produce.

But tho' *Antiquity* thus gave its *Vote* for *Terreſtrial Matter*, ſeveral of the *Moderns*, and ſome of very *great Name* too, both *here* and *abroad*, have gone quite Counter, and given *theirs* in behalf of *Water*. The *dignity* of the *Perſons* that have eſpouſed it, as well as their *number*, renders this Doctrine very conſiderable, and well worth our enquiring into. The great reſtorer of *Philoſophy* in this laſt Age, my Lord *Bacon*, is of opinion, *That for Nouriſhment of* Vegetables, *the Water is almoſt all in all: and that the Earth doth but keep the Plant upright, and ſave it from over heat, and over cold* †. Others there are who are ſtill more expreſs: and aſſert Water

* *Terra Parens.* Γῆ μήτηρ πάντων. *Terra Mater.*

† *Nat. Hiſt. Cent.* 5. § 411.

to be the only *Principle* or Ingredient of all natural things. They ſuppoſe that, by I cannot tell what Proceſs of Nature, Water is *tranſmuted* into *Stones*, into *Plants*, and, in brief, all other Subſtances whatever. *Helmont* || particularly, and his *Followers*, are very poſitive in this: and offer ſome *Experiments* to render it credible. Nay a very *extraordinary Perſon* of our own *Nation* * tries thoſe *Experiments* over again: and diſcovers a great Propenſity to the ſame Thoughts and Opinion they had; declaring for this *Tranſmutation of Water* into *Plants* and *other Bodies*, tho' with great Modeſty and Deference, which was his uſual manner.

The *Experiments* they inſiſt upon are cheifly *two*; the *firſt* is, that *Mint* and ſeveral *other Plants* proſper and thrive very greatly in *Water*. The *other* is this; they take a certain quantity of *Earth*, and *bake* it in an *Oven*: then they weigh it, and put it into an *Earthen Pot*. Having well water'd this *Earth*, they make choice of ſome fit *Plant*, which, being firſt carefully *weigh'd*, they *ſet* in it. There they let it grow, continuing to *Water* it for ſome time, till 'tis much advanced in *bigneſs*. Then they take it up; and tho' the *Bulk* and *Weight* of the *Plant* be much greater than when *firſt ſet*, yet upon *Baking* the *Earth*, and *weighing* it, as at firſt, they find it little or not at all *diminiſhed* in *weight*; and therefore conclude 'tis not the *Earth* but *Water* that nouriſhes and is *turn'd* into the Subſtance of the *Plant*.

I muſt confeſs I cannot ſee how *this Experiment* can ever be made with the *nicety* and *juſtneſs* that is requiſite, in order to *Build* upon it ſo *much* as *theſe Gentlemen* do. 'Tis hard to weigh *Earth* in that *quantity*, or *Plants* of the *ſize* of thoſe they mention, with any great *exactneſs*: or to *bake* the Earth with that *Accuracy*, as to reduce it *twice* to juſt the *ſame Dryneſs*. But I may wave all this [illegible] be never ſo ea-

|| plexio- itque Mi- Element.

* Boyl, Chym. 2.

ſily practicable, and all the Accidents of it exactly as they ſet forth, yet nothing like what they *infer* can poſſibly be concluded from it; unleſs *Water*, which they ſo plentifully beſtow upon the *Plant* in *this Experiment*, be *pure*, *homogeneous*, and not charged with any *terreſtrial Mixture*; for if it be, the Plant after all may owe its *growth* and *encreaſe* intirely to *that*.

Some *Waters* are indeed ſo very *clear* and *tranſparent*, that one would not eaſily ſuſpect any *terreſtrial Matter* were latent in them: but they may be *highly ſaturated* with ſuch *Matter*, tho' the Eye be not preſently able to deſcry or diſcern it. 'Tis true, *Earth* is an *opake Body*; but it may be ſo far diſſolved, reduced to ſo extreme ſmall Particles, and theſe ſo *diffuſed* through the *watery Maſs*, as not ſenſibly to impede *viſion*, or render the Water much the leſs *diaphanous*. *Silver* is an *Opake*, and indeed a very *denſe Body*; and yet, if perfectly *diſſolved* in *Sp.* of *Nitre*, or *Aqua Fortis*, that is *rectified* and thorowly *fine*, it does not *darken* the *Menſtruum*, or render it leſs *pellucid* than before *. And other Inſtances there are, that oftentimes *great quantities* of *Opake Matter* are ſuſtain'd in *Fluids*, without conſiderably ſtriking the *Eye*, or being perceived by it. So that were there *Water* any where found ſo *pure*, that the quickeſt Eye could diſcover in it no *terreſtrial intermixture*; *that* would be far ſhort of a *Proof*, that in reality there was *none*.

But after all, even the *cleareſt Water* is very far from being *pure* and wholly *defecate*, in any part of the *World*, that I can learn. For *Ours* here, I have had an Opportunity of Examining it over a good part of *England*: and cannot ſay I ever met with any, that, however *freſh* and *newly* taken out of the *Spring*, did not exhibit, even

* *Provided the* Silver *be* pure *and abſolutely* refin'd: *For the leaſt admixture of* Copper *will produce a* blue Tincture *in the* Menſtruum; that *of ſome* other Bodies, different.

to the naked Eye, *great numbers* of exceeding ſmall *terreſtrial Particles* diſſeminated through all parts of it. *Thicker* and *craſſer Water* exhibits *them* in ſtill greater *Plenty*.

Theſe are of two general *kinds*. The one a *vegetable terreſtrial Matter*, conſiſting of very different *Corpuſcles*; ſome whereof are proper for the formation and increment of *one ſort* of *Plant*, and ſome of *another*: as alſo ſome for the nouriſhment of *one part* of the *ſame Plant*, and ſome of another. The *other kind* of *Particles* ſuſtain'd in *Water* are of a *Mineral Nature*. Theſe likewiſe are of *different ſorts*. In ſome Springs we find *Common Salt*, in others *Vitriol*, in others *Alum*, *Nitre*, *Sparr*, *Ochre*, &c. nay frequently *ſeveral* of theſe, or other *Minerals*, all in the *ſame Spring*; the *Water* as it drains and paſſes thorow the *Strata* of Stone, Earth, and the like, *taking up* and *bearing* along ſuch looſe *Mineral Corpuſcles*, as it meets with in the pores and interſtices of thoſe *Strata*, and bringing them on with it quite to the *Spring*. *All Water* whatever is much charged with the *Vegetable Matter*, this being *fine*, *light* and *eaſily moveable*. For the *Mineral*, the Water of *Springs* contains more of it than that of *Rivers*, eſpecially when at *diſtance* from their *Sources*: and that of *Rivers* more than the Water that falls in *Rain*. This I have learn'd from ſeveral *Tryals*, which I muſt not give Account of here; my Drift in this place being only to evince the *exiſtence* of *terreſtrial Matter* in *Water*.

Any one who deſires *further ſatisfaction* in this, may eaſily obtain it, if he only put Water into a clear *Glaſs Viol*, ſtopping it cloſe, to keep Duſt and other exterior Matter out, and letting it ſtand, without ſtirring it for ſome *Days*. He'll then find a conſiderable Quantity of *terreſtrial Matter* in the *Water*, however pure and free it might appear when firſt put into the Viol. He'll in a very ſhort time obſerve,as I have frequently done,the *Corpuſcles* that were at firſt,while the *Water* was agitated and kept in *Motion*, ſeparate, and hardly viſible *, by degrees, as the Water permits, by its becoming more *ſtill* and at *reſt*, *aſſembling* and *combining* together; by that means forming ſomewhat *larger* and more *conſpicuous Moleculæ*. Afterwards he may behold *theſe* joining and *fixing* each to other, by that means forming large thin Maſſes, appearing like *Nubeculæ*, or Clouds in the *Water*; which grow more *thick* and *opake*, by the continual appulſe and *accretion* of *freſh Matter*. If the ſaid *Matter* be chiefly of the *Vegetable* kind, 'twill be *ſuſtained* in the *Water*: and diſcover at length a *green colour*; becoming ſtill more and more of that *Colour*, I mean an higher and more ſaturate *Green*, as the *Matter* thickens and encreaſes. That this *matter* inclines ſo much to that *Colour*, is the leſs ſtrange, ſince we ſee ſo large a ſhare of it, when conſtituting *Vegetables*, wearing the *ſame Colour* in *them*. But if there be any conſiderable quantity of meer *Mineral Matter* in the Water, *this*, being of a greater *ſpecifick gravity* than the *Vegetable*, as the *Particles* of it *unite* and *combine* in ſuch *Number*, till they form a *Molecula*, the impetus of whoſe *Gravity* ſurpaſſes *that* of the *Reſiſtance* of the Water, ſubſides a great deal of it to the *bottom*. Nor does it only fall down *it ſelf*, but, frequently entangling with the *Vegetable Nubeculæ*, forces *them* down along with it.

The reaſon why *Bodies*, when *diſſolved* and reduced to extreme *ſmall parts*, are ſuſtain'd in *Liquors* that are of leſs *ſpecifick Gravity* than thoſe *Bodies* are, hath been pointed at by a late *ingenious Member* of this *Society* *. He is indeed far from having adjuſted all the *Momenta* of this affair; however it muſt be admitted, that, in the *dividing* or *ſolution* of *Bodies*, their *Surfaces* do not decreaſe in the *ſame Proportion* that their *Bulk* does.

Now

* *To ſay nothing of* thoſe *that were* not diſcernible.

* Mr. *W. Molineux*, *Philoſ. Tranſ.* N° 181.

Now the *Gravity* of a *Body* which is the *Cauſe* of its *ſinking* or tendency downwards, is commenſurate to its *Bulk* : but the *Reſiſtance* that the *Liquor* makes is proportion'd , not to the *Bulk*, but to the extent of the *ſurface* of the *Body* immerſed in it. Whence 'tis plain, a *Body* may be ſo far divided , that its *Parts* may be ſuſtain'd in a *Fluid*, whoſe *Specifick Gravity* is *leſs* than *that* of the ſaid *Body*. Nay, 'tis matter of Fact that they frequently are ſo : and we daily ſee *Menſtrua* ſupporting the Parts of *Metalls*, and other Bodies, that are of ſix, ten, nay almoſt twenty times the Spec. Grav. of thoſe *Menſtrua*. And as the *Parts* of *Bodies* when *divided* are thus *ſupported* in a *Fluid* : So when they *occur* and *unite* again , they muſt *ſink* of Courſe , and *fall* to the *Bottom*.

Upon the whole, 'tis palpable and beyond reaſonable Conteſt, that *Water* contains in it a very conſiderable Quantity of *terreſtrial Matter*. Now the Queſtion is to which of *theſe*, the *Water*, or the *Earthy Matter* ſuſtain'd in it, *Vegetables* owe their *Growth* and *Augment*. For deciding of which I conceive the following *Experiments* may afford ſome *Light* : And I can ſafely ſay they were made with due *Care* and *Exactneſs*.

Anno 1691.

I choſe ſeveral *Glaſs Viols*, that were all, as near as poſſible, of the *ſame ſhape* and *bigneſs*. After I had put what Water I thought fit into every one of them, and taken an *Account* of the *weight* of it, I ſtrain'd and ty'd over the Orifice of each Viol, a piece of *Parchment*, having an hole in the middle of it, large enough to admit the *Stem* of the *Plant* I deſign'd to ſet in the Viol, without *confining* or *ſtraightning* it ſo as to impede its *Growth*,

Growth. My intention in *this*, was to prevent the encloſed *Water* from *Evaporating*, or aſcending any other way than only thorow the *Plant* to be ſet therein. Then I made choice of ſeveral Sprigs of *Mint*, and *other Plants*, that were, as near as I could poſſibly judge, alike *freſh*, *ſound*, and *lively*. Having taken the *weight* of *each*, I placed it in a Viol, ordered as above: and as the *Plant* imbibed and drew off the *Water*, I took care to add more of the ſame from time to time, keeping an *Account* of the *weight* of all I *added*. Each of the Glaſſes were, for better *diſtinction*, and the more eaſy keeping a *Regiſter* of all *Circumſtances*, noted with a different Mark or *Letter*, *A*, *B*, *C*, &c. and all ſet in a Row in the ſame *Window*, in ſuch manner that all might partake alike of *Air*, *Light*, and *Sun*. Thus they continued from *July* the Twentieth, to *October* the Fifth, which was juſt Seventy Seven Days. Then I took them out, *weigh'd* the *Water* in each Viol, and the *Plant* likewiſe, adding to its *Weight* that of all the *Leaves* that had *fallen off* during the time it ſtood thus. And Laſtly, I computed how much each *Plant* had *gain'd*: and how much *Water* was *ſpent* upon it. The *Particulars* are as follows.

	The Weight of the Plant when firſt ſet in Water	The Wt. of the Pl. when tak'n again out of the Water	The Wt. gain'd by the Plant during th' 77 days	The Wt. of the Wat. expended upon the Plant	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
A. *Common Spear-Mint*, ſet in *Spring-Water*. The Plant weighed, when put in *July* 20. juſt 27 Grains: when taken forth, *Octob.* 5. 42 grains. So that in this ſpace of 77 days, it had gained in weight 15 grains. The whole quantity of Water expended, during theſe 77 days, amounted to 2558 gr. Conſequently the weight of the Water taken up was $170\frac{8}{15}$ times as much as the Plant had got in weight.	*gr.* 27	*gr.* 42	*gr.* 15	*gr.* 2558	As 1 to $170\frac{8}{15}$
B. *Common Spear-Mint: Rain water.* The Mint weigh'd, when put in, gr. $28\frac{1}{4}$; when taken out gr. $45\frac{3}{4}$. having gain'd in 77 days gr. $17\frac{1}{2}$. The diſpendium of the Water gr. 3004. which was $171\frac{23}{35}$ times as much as the Plant had received in weight.	*gr.* $28\frac{1}{4}$	*gr.* $45\frac{3}{4}$	*gr.* $17\frac{1}{2}$	*gr.* 3004	As 1 to $171\frac{23}{35}$
C. *Common Spear mint: Thames Water.* The Plant when put in gr. 28. when taken forth, gr. 54. So that in 77 days it had gain'd gr. 26. The Water expended amounted to gr. 2493. which was $95\frac{23}{26}$ times as much as the additional weight of the Mint.	*gr.* 28	*gr.* 54	*gr.* 26	*gr.* 2493	As 1 to $95\frac{23}{26}$

D. *Common Solanum,* or *Night ſhade: Spring Water.* The Plant weigh'd, when put in, gr. 49: when taken out 106. having gain'd in 77 days 57 gr.

The Wat. expended during the ſaid time was 3708 gr. which was $65\frac{3}{57}$ times as much as the augment of the Plant.

This ſpecimen had ſeveral *Buds* upon it, when firſt ſet in the Wat. *Theſe* in ſome days, became fair *Flowers*, which were at length ſucceeded by *Berries*.

E. *Lathyris ſeu Cataputia Gerb: Spring Water.* It weigh'd, when put in, gr. 98. when taken forth, gr. $101\frac{1}{2}$. The additional weight for this whole 77 days being but gr. $3\frac{1}{2}$.

The quantity of Wat. ſpent upon it during that time, gr. 2501. which is $714\frac{4}{7}$ times as much as the Plant was augmented.

The Weight of the Plant when firſt ſet in Water	The Wt. of the Pl. when taken again out of the Water	The Wt. gain'd by the Plant during the 77 days	The Wt. of the Wat. expended upon the Plant	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
gr.	*gr.*	*gr.*	*gr.*	
49	106	57	3708	As 1 to $65\frac{3}{57}$.
gr.	*gr.*	*gr.*	*gr.*	
98	$101\frac{1}{2}$	$3\frac{1}{2}$	2501	As 1 to $714\frac{4}{7}$.

Several *other Plants* were try'd, that did *not thrive* in *Water*, or ſucceed any better than the *Cataputia* foregoing: But 'tis beſides my purpoſe to give a particular *Account* of *them* here.

F, G. *Theſe Two Viols* were fill'd, the former (F) with *Rain*, the other with *Spring Water*, at the ſame time as thoſe above-mentioned were: and ſtood as long as they did. But they had neither of them any Plant;

my

my Deſign in theſe being only to inform my ſelf, whether any *Water exhaled* out of the *Glaſſes*, otherwiſe than *thorow* the *Bodies* of the *Plants*. The Orifices of theſe Two Glaſſes were cover'd with *Parchment*; each piece of it being perforated with an hole of the ſame bigneſs with *thoſe* of the Viols above. In this I ſuſpended a bit of Stick about the thickneſs of the *Stem* of one of the aforeſaid *Plants*, but not reaching down to the *Surface* of the included *Water*. I put them in thus, that the *Water* in *theſe* might not have more ſcope to evaporate than *that* in the other Viols. Thus they ſtood the whole 77 days in the ſame Window with the reſt; when, upon Examination, I found *none* of the *Water* in theſe *waſted* or *gone off*. Tho' I obſerved, both in *theſe*, and the *reſt*, eſpecially after *hot Weather*, ſmall *drops* of *Water*, not unlike *Dew*, adhering to the *inſides* of the *Glaſſes*, that part of them I mean that was above the *Surface* of the encloſed *Water*.

The Water in theſe two Glaſſes that had *no Plants* in them, at the end of the Experiment, exhibited a *larger* quantity of *terreſtrial Matter* than *that* in any of *thoſe* that *had* the *Plants* in them *did*. The *Sediment* at the bottom of the *Viols* was *greater*: and the *Nubeculæ* diffus'd through the Body of the Water *thicker*. And of *that* which was in the *others*, ſome of it proceeded from certain ſmall *Leaves* that had fallen from that part of the Stems of the Plants that was within the Water, wherein they *rotted* and *diſſolved*. The *terreſtrial Matter* in the *rain Water* was *finer* than that in the *ſpring Water*.

Anno 1692.

The *Glaſſes* made uſe of in *this*, were of the ſame ſort with thoſe in the *former Experiment*: and cover'd over with Parchment in like manner. The *Plants* here were all *Spear mint*: the moſt kindly, freſh, ſprightly Shoots I could chooſe. The *Water*, and the *Plants*, were *weigh'd* as above: and the *Viols* ſet, in a Line, in a *South-Window*; where they ſtood from *June* 2d, to *July* 28. which was juſt 56 days.

H. *Hyde-Parke Conduit-Water*, alone. The *Mint* weighed, when put in, 127 gr: when taken out, 255 gr. The whole quantity of Water expended upon this Plant amounted to 14190 gr.

This was all along a very *kindly Plant*: and had run up to above two foot in *height*. It had ſhot but one conſiderable *collateral branch*: but had ſent forth many and long *Rootes*, from which ſprung very numerous tho' ſmall, and ſhort leſſer *Fibres*. Theſe leſſer Roots came out of the larger on two oppoſite ſides, for the moſt part; ſo that each Root, with its *Fibrillæ*, appear'd not unlike a ſmall *Feather*. To theſe *Fibrillæ* adher'd pretty much *terreſtrial Matter*. In the *Water* which was at laſt thick and turbid, was a *green ſubſtance* reſembling a fine thin *Conferva*.

The Weight of the Plant when firſt ſet in Water	The Wt. of the Pl. when taken again out of the Water	The Wt. gain'd by the Plant during the 56 days	The Wt. of the Wat. expended upon the Plant	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
gr.	*gr.*	*gr.*	*gr.*	
127	255	128	14190	As 1 to 110$\frac{110}{128}$

	The Weight of the Plant when firſt ſet in Water.	The Wt. of the Pl. when tak'n again out of the Water.	The Wt. gain'd by the Plant during the 56 days.	The Wt. of the Wat. expended upon the Plant.	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
I. The *ſame Water*, alone. The *Mint* weigh'd, when put in, 110 gr: when taken out, 249. Water expended, 13140 gr. *This Plant* was as *kindly* as the former, but had ſhot no collateral Branches. Its *Roots*, the *Water*, and the *green Subſtance*, all much as in the former.	gr. 110	gr. 249	gr. 139	gr. 13140	As 1 to $94\frac{74}{139}$
K. *Hyde-Park Conduit-Water* in which was diſſolved an Ounce and half of *Common Garden Earth*. The *Mint* weigh'd, when put in, 76 gr: When taken out 244 gr. Water expended, gr. 10731. This *Plant*, tho' it had the Misfortune to be annoyed with many ſmall *Inſects* that happened to fix upon it, yet had ſhot very conſiderable collat. *Branches*: and at leaſt as many *Roots* as either that in H. or I; which had a *much greater* quantity of *terreſtrial Matter* adhering to the extremities of them. The ſame *green Subſtance* here, that was in the two preceding.	gr. 76	gr. 244	gr. 168	gr. 10731	As 1 to $63\frac{147}{168}$.

	The Weight of the Plant when firſt ſet in Water.	The Wt. of the Pl. when tak'n again out of the Water.	The Wt. gain'd by the Pl. during the 56 days.	The Wt. of the Wat expended upon the Plant.	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
L. *Hyde-Park Water*, with the ſame quantity of *Garden Mould* as in the former. The *Mint* weigh'd, when put in, 92 gr: when taken out 376 gr. The Water expended, 14950 gr. *This Plant* was far *more flouriſhing* than any of the Precedent: had ſeveral very conſiderable collateral *Branches*: and very *numerous Roots*, to which *terreſtrial Matter* adhered very copiouſly. The *Earth* in both theſe Glaſſes was very ſenſibly and conſiderably *waſted*, and *leſs* than when firſt put in. The ſame ſort of *green Subſtance* here as in thoſe above.	*gr.* 92	*gr.* 376	*gr.* 284	*gr.* 14950	As 1 to 52 $\frac{182}{284}$.
M. *Hyde-Park Water*, *deſtilled* off with a gentle *Still*. The *Mint* weigh'd, when put in, 114 gr: when taken out, 155. The Water expended, 8803 *gr*. *This Plant* was *pretty kindly*: had 2 ſmall collat. *Branches*, and ſeveral *Rootes*, tho' *not ſo many* as that in H or I, but as much *terreſtrial Matter* adhering to them as thoſe had. The Water was pretty *thick*; having very numerous ſmall *terreſtrial Particles* ſwimming in it, and ſome *Sediment* at the bottom of the Glaſs. This Glaſs had none of the *green Matter* above-mentioned, in it.	*gr.* 114	*gr.* 155	*gr.* 41	*gr* 8803	As 1 to 214 $\frac{29}{41}$.

N. The *reſidue of the Water* which remain'd in the *Still* after that in M. was deſtilled off. It was very *turbid*, and as high-coloured (reddiſh) as ordinary *Beer*. The *Mint* weigh'd, when put in, 81 gr: when taken out, 175 gr. Water expended, 4344 gr. This *Plant* was very lively: and had ſent out ſix collateral *Branches*, and ſeveral *Roots*.

The Weight of the Plant when firſt ſet in Water.	The Wt. of the Pl. when tak'n again out of the Water.	The Wt. gain'd by the Pl. during the 56 days.	The Wt. of the Wat. expended upon the Plant.	The Proportion of the Encreaſe of the Plant to the Expence of the Water.
gr.	*gr.*	*gr.*	*gr.*	
81	175	94	4344	As 1 to $46\frac{20}{94}$

O. *Hyde-Park Conduit-Water*, in which was diſſolved a Drachm of *Nitre*. The *Mint* ſet in this ſuddenly began to *wither* and *decay*; and *dyed* in a few Days. As likewiſe did two more *Sprigs*, that were ſet in it, ſucceſſively. In another Glaſs I diſſolved an Ounce of good Garden *Mould*, and a Drachm of *Nitre*: and in a third half an Ounce of *Wood-Aſhes*, and a Drachm of *Nitre*; but the *Plants* in *theſe* ſucceeded no better than in the *former*. In *other Glaſſes* I diſſolved ſeveral *other ſorts of Earths*, *Clays*, *Marles*, and variety of *Manures*, &c. I ſet *Mint* in *diſtill'd Mint-Water*; and other *Experiments* I made, of ſeveral kinds, in order to get light and information what *haſtened* or *retarded*, *promoted* or impeded *Vegetation*; but theſe do not belong to the *Head* I am now upon.

P *Hyde Parke Conduit Water*. In this I fixed a *Glaſs-Tube* about ten Inches long, the *Bore* about one ſixth of an Inch in Diameter, fill'd with very fine and white *Sand*, which I kept from falling down out of the *Tube* into the *Viol*, by tying a thin piece of *Silk* over that end of the *Tube* that was downwards. Upon immerſion of the lower end of it into the Water, *this* by little and little *aſcended* quite to the upper Orifice of the *Tube*.

And yet, in all the fifty ſix days which it ſtood thus, a very inconſiderable quantity of *Water* had *gone off*, *viz.* ſcarcely Twenty Grains; tho' the *Sand* continued *moiſt* up to the *top* till the very laſt. The *Water* had imparted a *green* Tincture to the *Sand*, quite to the very top of the Tube. And, in the Viol, it had precipitated a *greeniſh Sediment*, mixt with *black*. To the bottom and ſides of the *Tube*, as far as 'twas immers'd in the Water, adher'd pretty much of the *green Subſtance* deſcribed above. Other like Tubes I fill'd with *Cotton*, *Lint*, *Pith of Elder*, and ſeveral other porous *Vegetable Subſtances*; ſetting ſome of them in *clear Water*: Others in Water tinged with *Saffron. Cochinele*, &c. And ſeveral other *Trials* were made, in order to give a *Mechanical Repreſentation* of the *Motion* and *Deſtribution* of the *Juices* in *Plants*: and of ſome other *Phenomena* obſervable in *Vegetation*, which I ſhall not give the particulars of *here*, as being not of Uſe to my *preſent Deſign*.

Q, R, S, &c. Several *Plants* ſet in Viols, ordered in like manner as *thoſe* above, in *October*, and the following *colder Months*. Theſe *throve* not *near ſo much*: nor did the *Water* aſcend in *nigh the quantity*, it did in the *hotter Seaſons*, in which the before recited *Trials* were made.

Some Reflections upon the foregoing Experiments.

1. *In Plants of the ſame kind, the leſs they are in Bulk, the ſmaller the Quantity of the Fluid Maſs in which they are ſet is drawn off; the Diſpendium of it, where the Maſs is of equal thickneſs, being pretty nearly proportioned to the Bulk of the Plant.* Thus *that* in the Glaſs Mark'd A, which weigh'd only 27 gr. drew off

but 2558 grains of the *Fluid*: and *that* in B, which weigh'd only 28¼, took up but 3004 gr. whereas that in H, which weigh'd 127 grains, ſpent 14190 gr. of the *Liquid Maſs.*

The *Water* ſeems to aſcend up the *Veſſels* of *Plants* in much the ſame manner as up a *Filtre*: and 'tis no great wonder that a *larger Filtre* ſhould draw off *more Water* than a leſſer: or that a *Plant* that has *more* and *larger Veſſels* ſhould take up a *greater* ſhare of the *Fluid*, in which 'tis ſet, than one that has *fewer* and *ſmaller* ones can. Nor do I Note *this* as a thing very conſiderable in it ſelf, but chiefly in regard to what I am about to offer *beneath*: And that it may be ſeen that, in my *other Collations* of *Things*, I made *due Allowance* for this *Difference.*

2. *The much greateſt part of the Fluid Maſs that is thus drawn off and convey'd into the Plants, does not ſettle or abide there: but paſſes through the Pores of them, and exhales up into the Atmoſphere.* That the *Water* in theſe Experiments, aſcended *only* through the *Veſſels* of the *Plants* is certain. The *Glaſſes* F and G, that had *no Plants* in them, tho' diſpoſed of in like manner as the *reſt*, remain'd, at the End of the *Experiment*, as at firſt: and *none* of the *Water* was gone off. And that the greateſt part of it flies off from the *Plant* into the *Atmoſphere*, is as certain. The leaſt *proportion* of the *Water* expended was to the *Augment* of the *Plant*, as 46 or 50 to 1. And in ſome the weight of the *Water* drawn off was 100, 200, nay, in one above 700 times as much as the Plant had received of *Addition.*

This ſo continual an *Emiſſion* and *Detachment* of *Water*, in ſo great *Plenty* from the *Parts* of *Plants*, affords us a manifeſt reaſon why *Countries* that *abound* with *Trees* and the *larger Vegetables* eſpecially, ſhould be very obnoxious to *Damps*, great *Humidity* in the *Air*, and more frequent Rains, than *others* that are more *open* and *free*. The great *Moiſture* in the *Air*, was a mighty inconvenience and *annoyance* to thoſe who firſt ſettled in *America*; which at that time was much over-grown with *Woods* and *Groves*. But as *theſe* were *burnt* and *deſtroyed*, to make way for *Habitation* and *Culture* of the *Earth*, the *Air* mended and *cleared* up apace: changing into a Temper much more *dry* and *ſerene* than before.

Nor does this *Humidity* go off *pure* and *alone*; but uſually bears forth with it many *parts* of the *ſame Nature* with *thoſe* whereof the *Plant*, through which it paſſes, conſiſts. The *Craſſer* indeed are not ſo eaſily born up into the *Atmoſphere*: but are uſually depoſited on the *Surface* of the *Flowers*, *Leaves*, and other Parts of the Plants. Hence come our *Manna's*, our *Honies*, and other *Gummous Exſudations* of *Vegetables*. But the *finer* and *lighter Parts* are with greater eaſe ſent up into the *Atmoſphere*. Thence they are conveyed to our Organs of *Smell*, by the *Air* we draw in *Reſpiration*: and are *pleaſant* or *offenſive*, *beneficent* or *injurious* to us, according to the *Nature* of the *Plants* from whence they ariſe. And ſince *theſe* owe their *Riſe* to the *Water* that aſcends out of the Earth through the Bodies of *Plants*, we cannot be far to ſeek for the Cauſe why *they* are more *numerous* in the *Air*, and we find a greater quantity of *Odours* exhaling from *Vegetables*, in *warm*, *humid ſeaſons*, than in any others whatever.

3. *A great part of the terreſtrial Matter that is mixt with the Water, aſcends up into the Plant as well as the Water.* There was *much more* terreſtrial Matter at the end of the Experiment, in the *Water* of the Glaſſes F and G, that had *no Plants* in them, than in thoſe

that had *Plants*. The *Garden-Mould* diſſolved in the Glaſſes K and L was conſiderably *diminiſhed*, and *carried off*. Nay the *terreſtrial* and *Vegetable Matter* was born up in the *Tubes* filled with *Sand*, *Cotton* &c. in that *quantity* as to be *evident* even to *ſenſe*. And the *Bodies* in the Cavities of the other *Tubes* that had their lower Ends immers'd in Water wherein *Saffron*, *Cochinele*, &c. had been infuſed, were *tinged* with *Yellow*, *Purple*, &c.

If I may be permitted to look abroad a while, towards our *Shores* and *Parts* within the Verge of the *Sea*, theſe will preſent us with a large ſcene of *Plants* that, along with the *Vegetable*, take up into them *meer mineral Matter* alſo in great *abundance*. Such are our *Sea-Purſlains*, the ſeveral ſorts of *Alga's*, of *Sampires*, and other *Marine Plants*. Theſe contain *common Sea-Salt*, which is all one with the *Foſſil*, in ſuch *Plenty*, as not only to be plainly diſtinguiſh'd on the *Palate*, but may be drawn forth of them in *conſiderable quantity*. Nay, there want not *thoſe* who affirm there are *Plants* found that will yield *Nitre*, and other *mineral Salts*; of which indeed I am not ſo far ſatisfied that I can depend on the Thing, and therefore give this only as an *Hint* for *Enquiry*.

To go on with the Vegetable Matter, how apt and how much diſpoſed this, being ſo very *fine* and *light*, is to *attend Water* in all its *Motions*, and *follow* it into each of its *Receſſes*, is manifeſt, not only from the *Inſtances* above alledg'd, but many others. *Percolate* it with all the Care imaginable: *Filter* it with never ſo many Filtrations, yet ſome terreſtrial *Matter* will remain. 'Tis true the *Fluid* will be *thinner* every time than other, and more diſingaged of the ſaid Matter: but never *wholly free and clear*. I have filtred Water thorow ſeveral ~~wholly free and clear~~ Sheets of *thick Paper*: and, after that, through very *cloſe* fine *Cloth* twelve times *doubled*. Nay, I have done this over and over ; and yet a conſiderable quantity of this *Matter* diſcover'd it ſelf in the *Water* after all. Now if it thus paſs *Interſtices* that are ſo very *ſmall* and *fine* along with the Water, 'tis the leſs ſtrange it ſhould *attend* it in its paſſage through the *Ducts* and *Veſſels* of *Plants.* 'Tis true, *filtering* and *diſtilling* of Water intercepts and makes it quit ſome of the *Earthy Matter* it was before impregnated withal : but then *that* which continues with the *Water* after this, is *fine* and *light* ; and ſuch conſequently as is in a peculiar manner fit for the *Growth* and *Nouriſhment* of *Vegetables.* And this is the Caſe of *Rain Water.* The *quantity* of *terreſtrial Matter* it bears up into the *Atmoſphere* is not great. But that which it does bear up, is mainly of that *light* kind of *Vegetable Matter* ; and that too perfectly *diſſolved*, and reduced to ſingle *Corpuſcles*, all *fit* to enter the *Tubules* and Veſſels of Plants. On which Account 'tis that *this Water* is ſo very *fertile* and *prolifique.*

The reaſon why in *this Propoſition* I ſay only *a great part* of the terreſtrial Matter that is mix'd with the Water, aſcends up with it into the *Plant*, is, becauſe *all of it* cannot. The *mineral Matter* is a great deal of it not only *groſs* and *ponderous*, but *ſcabrous* and *inflexible* : and ſo not diſpoſed to enter the *Pores* of the *Roots.* And a great many of the *ſimple* Vegetable Particles by degrees *unite*, and form ſome of them ſmall *Clods* or *Moleculæ* ; ſuch as thoſe mentioned in H, K, and L, ſticking to the extremities of the Roots of thoſe Plants. Others of them *intangle* in a *looſer manner* : and form the *Nubeculæ*, and *green Bodies* ſo commonly obſerved in *ſtagnant Water.* *Theſe*, when thus *conjoyn'd*, are *too big* to enter the *Pores*, or aſcend up the *Veſſels* of Plants, which *ſingly* they might have done. They who are converſant in *Agriculture* will eaſily ſubſcribe to *this.* They are well aware that, be their *Earth* never ſo *rich*, ſo *good*, and ſo *fit* for the Production of *Corn* or other *Vegetables*, little will come of it, unleſs the *Parts* of it be *ſeparated* and *looſe*. 'Tis on this Account they beſtow the Pains they do in *Culture* of it: in *Digging*, *Plowing*, *Harrowing*, and *Breaking* of the *Clodded Lumps* of Earth. 'Tis the ſame way that *Sea-Salt*, *Nitre*, and *other Salts* promote *Vegetation*. I am ſorry I cannot ſubſcribe to the *Opinion* of thoſe *Learned Gentlemen* who imagine *Nitre* to be *eſſential* to *Plants*: and that nothing in the *Vegetable Kingdom* is tranſacted without it. By all the *Tryals* I have been able to make, the thing is *quite otherwiſe*: and when contiguous to the *Plant* it rather deſtroys than nouriſhes it. But this, *Nitre* and *other Salts* certainly do: they *looſen* the *Earth*, and *ſeparate* the *concreted Parts* of it; by that means fitting and diſpoſing them to be *aſſumed* by the *Water*, and *carried up* into the *Seed* or *Plant*, for its *Formation* and *Augment*. There's no Man but muſt obſerve how apt all *ſorts* of *Salts* are to be wrought upon by *Moiſture*: how eaſily they *liquate* and *run* with it; and when theſe are *drawn* off, and have *deſerted* the Lumps wherewith they were incorporated, *thoſe* muſt *moulder* immediately, and fall *aſunder* of Courſe. The hardeſt *Stone* we meet with, if it happen, as frequently it does, to have any ſort of *Salt* intermixt with the *Sand* of which it conſiſts, upon being expos'd to an *humid Air*, in a ſhort time diſſolves and crumbles all to pieces: and much more will clodded *Earth* or *Clay*, which is not of near ſo *compact* and *ſolid* a *Conſtitution* as *Stone* is. The *ſame way* likewiſe is *Lime* ſerviceable in *this Affair*. The *Husbandmen* ſay of it, that it does not *fatten*, but only *Mellowes* the Ground. By which they mean, that it does not contain any thing in it ſelf that is of the *ſame Nature* with the *Vegetable Mould*, or afford any *Matter* fit for the *formation* of *Plants*: but meerly *ſoftens* and *relaxes* the

Earth; by that means rendering it more capable of *entering* the *Seeds* and *Vegetables* ſet in it, in order to their *Nouriſhment*, than otherwiſe it would have been. The *Properties* of *Lime* are well known: and how apt 'tis to be put into *ferment* and *commotion* by *Water*. Nor can ſuch *Commotion* ever happen when *Lime* is *mix'd* with *Earth*, however *hard* and *clodded* that may be, without *opening* and *looſening* of it.

4. *The Plant is more or leſs nouriſh'd and augmented in proportion as the Water in which it ſtands contains a greater or ſmaller quantity of proper terreſtrial Matter in it.* The Truth of this Propoſition is ſo eminently diſcernible through the *whole Proceſs* of theſe *Tryals*, that I think no *doubt* can be made of it. The *Mint* in the Glaſs C. was of much the ſame *Bulk* and *Weight* with *thoſe* in A. and B. But the *Water*, in which *that* was, being *River Water*, which was apparently ſtored more copiouſly with *terreſtrial Matter* than the *Spring* or *Rain Water*, wherein *they* ſtood, were; it had *thriven* to almoſt *double the Bulk* that either of them had; and with a *leſs Expence* of *Water* too. So likewiſe the Mint in L. in whoſe *Water* was diſſolved a ſmall quantity of good *Garden Mould*, tho' it had the diſadvantage † to be *leſs* when firſt ſet than either of the *Mints* in H. or I. whoſe *Water* was the very ſame with this in L. but had none of that *Earth* mix'd with it; yet, in a ſhort time the *Plant* not only *overtook*, but much *out-ſtripp'd* thoſe, and at the end of the Experiment was very conſiderably *bigger* and *heavier* than either of them. In like manner the *Mint* in N. tho' *leſs* at the beginning than *that* in M. being ſet in that *thick*, *turbid*, *feculent Water*, that remained behind, after *that*, wherein M. was placed, was *Still'd* off, had in fine more than *doubled* its *original weight* and *bulk*: and received above *twice* the *additional* *Encreaſe*

† *Confer.* *Prop.* I. *ſupra.*

creaſe that *that* in M. which ſtood in the *thinner deſtill'd Water*, had done. And, which is not leſs conſiderable, had not drawn off *half* the *Quantity* of *Water* that *that* had.

Why, in the biginning of this Article, I limit the *Proportion* of the *Augment* of the *Plant* to the *Quantity* of *proper* terreſtrial Matter in the *Water*, is, becauſe *all*, even the *Vegetable Matter*, to ſay nothing of the *Mineral*, is not *proper* for the Nouriſhment of *every Plant*. There may be, and doubtleſs are, *ſome Parts* in *different Species* of *Plants*, that may be much alike, and ſo ow their ſupply to the ſame *common Matter*: but 'tis plain *all* cannot. And there are *other Parts* ſo *differing*, that 'tis no ways credible they ſhould be form'd all out of the *ſame ſort* of Corpuſcles. So far from it, that there want not good Indications, as we ſhall ſee by and by, that *every Kind* of *Vegetable* requires a *peculiar* and *ſpecifick Matter* for its *Formation* and *Nouriſhment*. Yea, *each Part* of the *ſame Vegetable* does ſo: and there are very *many* and *different Ingredients* go to the *Compoſition* of the ſame individual *Plant*. If therefore the *Soil*, wherein any *Vegetable* or *Seed* is planted, contains *all* or *moſt* of *theſe Ingredients*, and thoſe in due *quantity*, 'twill *grow* and *thrive* there: otherwiſe 'twill *not*. If there be not as many *ſorts* of *Corpuſcles* as are requiſite for the *Conſtitution* of the *main* and *more eſſential* Parts of the *Plant*, 'twill *not* proſper at all. If there be *theſe*, and not in ſufficient *Plenty*, 'twill ſtarve, and never arrive to its natural *Stature*. Or if there be any the *leſs neceſſary* and *eſſential* Corpuſcles wanting, there will be ſome *Failure* in the *Plant*: 'twill be defective in *Taſte*, in *Smell*, in *Colour*, or ſome other way. But tho' a *Tract* of *Land* may happen not to contain *Matter* proper for the *Conſtitution* of ſome one *peculiar kind* of *Plant*: yet it may for ſeveral *others*, and thoſe much *differing* *ſering* amongſt themſelves. The *vegetative Particles* are *commixt* and blended in the *Earth*, with all the *diverſity* and *variety*, as well as all the *uncertainty* conceivable. I have given ſome *Intimations* of this *elſewhere* †, and ſhall not repeat them *here:* but hope in *due time* to put them into a much *better light* than *that* they *there* ſtand in.

† *Nat. Hiſt. Earth*, p. 228. & ſeq.

It is not poſſible to imagine how *one*, *uniform*, *homogeneous Matter*, having its *Principles* or *Original Parts* all of the *ſame Subſtance*, *Conſtitution*, *Magnitude*, *Figure*, and *Gravity*, ſhould ever conſtitute *Bodies* ſo egregiouſly *unlike*, in all *thoſe reſpects* as *Vegetables* of *different kinds* are: nay even as the *different Parts* of the *ſame Vegetable*. That *one* ſhould carry a *Reſinous*, another a *Milky*, a third a *Yellow*, a fourth a *Red Juice*, in its *Veins:* one afford a *Fragrant*, another an *offenſive ſmell:* one be *ſweet* to the *Taſte*, another *bitter*, *acid*, *acerb*, *auſtere*, &c. that one ſhould be *nouriſhing*, another *poyſonous*, one *purging*, another *aſtringent:* in brief, that there ſhould be that vaſt *difference* in them in their ſeveral *Conſtitutions*, *Makes*, *Properties*, and *Effects*, and yet *all* ariſe from the very *ſame ſort of Matter*, would be very *ſtrange*. And, to Note that by the by, this *Argument* makes *equally ſtrong* againſt *thoſe* who ſuppoſe *meer Water* the *Matter* out of which all *Bodies* are *form'd*.

The *Cataputia* in the Glaſs E. received but very little *Encreaſe*, only three grains and an half all the while it ſtood, tho' 2501 grains of Water were ſpent upon it. I will not ſay the reaſon was becauſe *that Water* did not contain in it Matter fit and *proper* for the Nouriſhment of that *peculiar* and *remarkable Plant*. No, it may be the *Water* was not a *proper* Medium for it to grow in: and we know there are very *many Plants* that will *not thrive* in it. Too much of that Liquor, in ſome Plants, may probably *hurry* the *terreſtrial Matter* thorow their *Veſſels* too faſt for them to *arreſt* and lay hold of it. Be that as it will, 'tis moſt certain there are *peculiar Soils* that ſuit *particular Plants.* In *England, Cherries* are obſerved to ſucceed beſt in *Kent*: *Apples* in *Herefordſhire*: *Saffron* in *Cambridgeſhire*: *Woad* in two or three of our *Midland Counties*: and *Teazles* in *Somerſetſhire.* This is an *Obſervation* that hath held in *all Parts,* and indeed in all *Ages* of the *World.* The moſt *ancient Writers* of *Husbandry* * took Notice of it: and are not wanting in their *Rules* for making choice of *Soils* ſuited to the *nature* of each kind of *Vegetable* they thought *valuable* or *worth propagating.*

But, which is a further *Proof* of what I am here endeavouring to advance, that *Soil* that is *once proper* and fit for the Production of ſome one ſort of *Vegetable* does not ever continue to be ſo. No, in *Tract of time* it looſes that Property: but *ſooner* in *ſome Lands,* and *later* in *others.* This is what all who are converſant in theſe things know very well. If *Wheat,* for Example, be ſown upon a Tract of Land that is proper for that *Grain,* the *firſt Crop* will ſucceed very well: and perhaps the *ſecond,* and the *third,* as long as the Ground is in *Heart,* as the *Farmers* ſpeak. But in a *few Years* 'twill produce *no more,* if ſowed with *that Corn.* Some *other Grain* indeed it may, as *Barly.* And after *this* has been ſown *ſo often* that the *Land* can bring forth *no more* of the ſame; it may afterwards yield good *Oats*: and perhaps *Peaſe* after them. *At length* 'twill become *Barren*; the *Vegetative Matter,* that at firſt it *abounded* withal, being *educed forth* of it by thoſe *ſucceſſive Crops,* and moſt of it *born off. Each ſort* of *Grain* takes forth *that peculiar Matter* that is *proper* for *its own Nouriſhment.* Firſt the *Wheat* draws off *thoſe Particles* that *ſuit* the Body of *that Plant*; the reſt lying all *quiet* and *undiſturbed*

* *Vid. Varronem, Columellam, & reliquos Rei Ruſticæ Scriptores.*

undiſturbed the while. And when the *Earth* has yielded up all them, *thoſe* that are *proper* for *Barly*, a *different Grain*, remain *ſtill behind*, 'till the ſucceſſive *Crops* of *that Corn* fetch *them* forth too. And ſo the *Oats*, and *Peaſe*, in their *Turn*; 'till in fine all is *carried off*, and the *Earth* in great Meaſure *drain'd* of *that ſort* of *Matter*.

After all which, *that very Tract* of *Land* may be brought to *produce* another *Series* of the *ſame Vegetables*: but never 'till 'tis *ſupplied* with a new *Fund* of *Matter*, of like *ſort* with *that* it at firſt *contain'd*. This *ſupply* is made *ſeveral ways*. By the Grounds *lying fallow* for ſome time, 'till the *Rain* has pour'd down a *freſh ſtock* upon it. Or by the *Tiller's Care* in Manuring of it. And for further Evidence that *this ſupply* is in reality of *like ſort*, we need only reflect a while upon thoſe *Manures* that are found by conſtant *Experience* beſt to promote *Vegetation*, and the *fruitfulneſs* of the *Earth*. Theſe are chiefly either *Parts* of *Vegetables*, or of *Animals*; which indeed either derive their own *Nouriſhment* immediately from *Vegetable Bodies*, or from other *Animals* that do ſo. In *particular*, the *Blood*, *Urine*, and *Excrements* of *Animals*: Shavings of *Horns* and of *Hoofs*: *Hair*, *Wool*, *Feathers*: *calcin'd Shells*: *Lees of Wine*, and of *Beer*: *Aſhes* of all ſorts of *Vegetable Bodies*: *Leaves*, *Straw*, *Roots*, and *Stubble*, turn'd into the *Earth* by *Plowing* or otherwiſe, to *rot* and *diſſolve* there; *theſe* I ſay are our beſt *Manures*, and, being *Vegetable Subſtances*, when refunded *back again* into the *Earth*, ſerve for the *formation* of *other like Bodies*.

Not wholly to Confine our Thoughts to the *Fields*, let us look a while into our *Gardens*; where we ſhall meet with ſtill further *Confirmations* of the ſame thing. The *Trees*, *Shrubs*, and *Herbs* Cultivated in *theſe*, after they have *continued* in one *Station* till they have *derived*

thence

thence the greater Part of the *Matter fit* for their *Augment*, will *decay* and *degenerate*, unleſs either *freſh Earth*, or ſome *fit Manure*, be applied unto them. 'Tis true, they may *maintain* themſelves *there* for ſome time by ſending forth *Roots* further and further to a *great extent* all round, to fetch in *more remote Proviſion*; but *at laſt* all will fail: and they muſt either have a *freſh ſupply* brought to them, or they *themſelves* be *removed* and *tranſplanted* to ſome Place *better furniſhed* with *Matter* for their *Subſiſtence*. And accordingly *Gardiners* obſerve that *Plants* that have *ſtood a great while* in a *Place*, have *longer Roots* than uſual; part of which they *cut off* when they *tranſplant them* to a *freſh Soil*, as now not of any further *uſe* to them. All theſe *Inſtances*, to paſs over a great many *others* that might be alledged, point forth a *Particular terreſtrial Matter*, and not *Water*, for the *Subject* to which *Plants* owe their *increaſe*. Were it *Water only*, there would be no need of *Manures*: or of *tranſplanting* them from place to place. The *Rain* falls in all *Places* alike: in *this Field* and in *that* indifferently: in *one ſide* of an *Orchard* or *Garden* as well as *another*. Nor could there be any reaſon why a *Tract* of *Land* ſhould yield *Wheat* one *Year* and not the next; ſince the *Rain* ſhowers down *alike* in *each*. But I am ſenſible I have carried on *this Article* to too great a *length*: which yet on ſo *ample* and *extenſive* a *Subject* 'twas not eaſy to avoid.

5. *Vegetables are not form'd of Water: but of a certain peculiar Terreſtrial Matter.* It hath been ſhewn, that there is a *conſiderable Quantity* of this *Matter* contain'd both in *Rain*, *Spring*, and *River Water*: that the much greateſt *part* of the *fluid Maſs* that aſcends up into *Plants* does *not ſettle* or *abide* there, but paſſes *through the Pores* of them and *exhales* up into the *Atmoſphere*:

that a *great part* of the *terreſtrial Matter*, mixt with the Water, *paſſes up* into the *Plant* along with it: and that the *Plant* is more or *leſs augmented* in proportion as the *Water* contains a *greater* or *ſmaller Quantity* of that *Matter*. From all which we may very reaſonably infer, that *Earth, and not Water, is the Matter that conſtitutes Vegetables.* The Plant in E drew up into it 2501 grains of the *Fluid Maſs*: and yet had received but gr. 3 and a half of *Encreaſe* from all that. The Mint in L. tho' it had at firſt the diſadvantage to be much leſs than that in I, yet being ſet in Water wherewith *Earth* was *plentifully* mix'd, and *that* in I *only in Water* without any ſuch *additional Earth*, it had vaſtly outgrown the other, weighing at laſt 145 gr. more than *that* did, and ſo having gain'd above twice as much as *that* had. In like manner *that* in K, tho' 'twas a great deal *leſs* when put in than *that* in I, and alſo was *impair'd* and *offended* by *Inſects*, yet being Planted in Water wherein *Earth* was *diſſolved*, whereas the *Water* in which I ſtood had *none*, it not only *over-took* but conſiderably *ſurpaſs'd* the *other*; weighing at laſt 29 gr. more than *that* in I, and yet had not expended *ſo much Water* as *that* by above 2400 gr. The Plant in N, tho' at firſt a great deal *leſs* than that in M, yet being ſet in the *foul craſs Water* that was left in the *Still*, after *that* in which M was ſet was drawn off, in Concluſion had *gain'd* in weight *above double* what that in the *finer* and *thinner* Water had. The *Proportion* of the *Augment* of *that Plant* that *throve moſt* was, to the *Fluid Maſs* ſpent upon it, but as 1 to 46. In *others* 'twas but as 1 to 60, 100, 200: nay in the Cataputia 'twas but as 1 to 714. The Mint in B took up 39 gr. of Water *a day*, one day with another; which was much more than the *whole weight* of the *Plant* originally: and yet with all *this* it *gain'd* not one fourth of a grain a day in *weight*. Nay *that* in H took up 253 gr. a day of the *Fluid*, which was near *twice* as much as its *original Weight*, it weighing, when firſt ſet in the Water but 127 gr. And after all, the *daily encreaſe* of the *Plant* was no more than gr. $2\frac{15}{56}$

6. *Spring and Rain-water contain pretty near an equal Charge of Vegetable Matter: River-water more than either of them.* The *Plants* in the Glaſſes A. B. and C. were at firſt of much the *ſame ſize* and *weight*. At the End of the Experiment the Mint in A had gain'd 15 gr. out of 2558 gr. of *Spring-water*: that in B gr. 17 and an half, out of 3004 gr. of *Rain-water*: but that in C had got 26 gr. out of only 2493. gr. of *River-water*. I do not found this Propoſition *ſolely* upon *theſe Tryals*; having made *ſome more*, which I do not relate here, that *agree* well enough with theſe. So that the *Proportions* here delivered will hold for the *main*: but a *ſtrict* and *juſt Compariſon* is hardly to be expected. So far from it, that I make no doubt but the *Water* that falls in *rain*, at *ſome times*, contains a *greater ſhare* of *terreſtrial Matter* than *that* which falls at others. A more *powerful* and *intenſe Heat* muſt needs hurry up a *larger quantity* of *that Matter* along with the *humid Vapors* that form *rain*, than one *more feeble* and *remiſs* ever poſſibly can. The *Water* of one *Spring* may flow forth with an *higher Charge* of this *Matter*, than *that* of *another*; this depending partly upon the *quickneſs* of the *Ebullition* of the *Water*: and partly upon the *Quantity* of that *Matter* latent in the *Strata* through which the Fluid paſſes, and the *greater* or *leſs laxity* of thoſe *Strata*. For the ſame Reaſon the *Water* of one *River* may *abound* with it *more* than *that* of *another*. Nay the *ſame River*, when *much agitated* and in *commotion*, muſt bear up *more* of it, than when it *moves* with *leſs rapidity* and *violence*.

That there is a *great quantity* of this *Matter* in *Rivers*: and that it *contributes* vaſtly to the *ordinary fertility* of the *Earth*, we have an illuſtrious Inſtance in the *Nile*, the *Ganges*, and *other Rivers* that *yearly overflow* the neighbouring *Plains*. Their *Banks* ſhew the *faireſt* and *largeſt Crops* of any in the *whole World*. They are even *loaded* with the *multitude* of their *Productions*: and thoſe who have not ſeen them will hardly be induced to believe the mighty *Returns* thoſe *Tracts* make in compariſon of *others* that have not the Benefit of like *Inundations*.

7. *Water ſerves only for a Vehicle to the terreſtrial Matter which forms Vegetables: and does not it ſelf make any addition unto them.* Where the *proper terreſtrial Matter* is *wanting*, the *Plant* is *not augmented* tho' never ſo much *Water* aſcend into it. The *Cataputia* in E took up *more Water* than the *Mint* in C, and yet had *grown* but very *little*, having received only three grains and an half of *additional weight*: whereas the other had received no *leſs* than twenty ſix grains. The Mint in I was planted in the ſame ſort of *Water* as that in K was; only the *latter* had *Earth* diſſolved in the Water; and yet *that* drew off 13140 gr. of the *Water*, gaining it ſelf *no more* than 139 gr. in weight: whereas the other took up *but* 10731. gr. of Water, and was *augmented* 168 gr. in weight. Conſequently *that* ſpent 2409 gr. more of the Water than *this* in K did, and yet was not *ſo much* encreaſed in *Weight* as *this* by 29 gr. The Mint in M ſtood in the very *ſame kind* of *Water* as that in N did. But, the *Water* in M having *much leſs* terreſtrial Matter in it than *that* in N had, the Plant bore up 8803 gr. of it, *gaining* it *ſelf* only 41 gr. the while: whereas that in N drew off *no more than* 4344 gr. and yet was augmented 94 gr.. So that *it* ſpent 4459 gr.

of *Water* more than *that* did: and yet was not *it ſelf* ſo much encreaſed in weight as *that* was by 53 gr. This is both a very *fair* and a very *concluſive* Inſtance: on which Account 'tis that I make oftner uſe of it. Indeed they are *all* ſo: and to add any thing further on *this Head* will not be needful.

'Tis evident therefore *Water* is not the *Matter* that compoſes *Vegetable Bodies.* 'Tis only the *Agent* that *conveys* that *Matter* to them: that *introduces* and *diſtributes* it to their ſeveral *Parts* for their *Nouriſhment.* That *Matter* is ſluggiſh and *inactive*: and would lye eternally confin'd to its *Beds* of *Earth,* without ever *advancing up* into *Plants*, did not *Water* or ſome like *Inſtrument*, fetch it *forth* and carry it unto them. That therefore there is that plentiful *Proviſion* and vaſt *Abundance* of it ſupplied to *all Parts* of the *Earth* is a mark of a *natural Providence* ſuperintending over the *Globe* we inhabit: and ordaining a due diſpenſation of that *Fluid*, without the *Miniſtry* of which the Noble *ſucceſſion* of *Bodies* we behold, *Animals*, *Vegetables*, and *Minerals* would be all at a ſtand †. But to keep to Plants; 'tis manifeſt *Water*, as well on this, as upon the other *Hypotheſis*, is abſolutely neceſſary in the Affair of *Vegetation*: and it will not *ſucceed* without it. *Which* indeed gave occaſion to the *Opinion* that *Water it ſelf* nouriſhed, and was *changed* into *Vegetable Bodies.* They ſaw, tho' *theſe* were planted in a *Soil* never ſo *rich*, ſo *happy*, ſo *advantageous*, nothing came of it unleſs there was *Water* too in conſiderable quantity. And it muſt be allowed *Vegetables* will not *come on* or *proſper* where *that* is wanting: But yet what *thoſe Gentlemen* inferr'd *thence* was not, we ſee, well grounded.

This *Fluid* is capacitated for the *Office* here aſſign'd it ſeveral ways. By the *Figure* of its *Parts*; which, as appears from many *Experiments*, is exactly and mathematically

† *Conf. Nat. Hiſt. Earth*, p. 47. & ſeq. uti & p. 128, *&c.*

matically *Sphærical*; their *ſurfaces* being perfectly *polite*, and without any the leaſt *inequalities.* 'Tis evident, *Corpuſcles* of ſuch a *Figure* are *eaſily ſuſceptible* of *Motion*, yea far above *any others* whatever: and conſequently the moſt capable of *moving* and *conveying* other *Matter* that is not ſo *active* and *voluble.* Then the *Intervalls* of Bodies of that *Figure* are, with reſpect to their *Bulk*, of all others the *largeſt*: and ſo the moſt fitted to *receive* and *entertain* foreign *Matter* in them. Beſides, as far as the *Tryals* hitherto made inform us, the *Conſtituent Corpuſcles* of *Water* are each ſingly conſider'd *abſolutely ſolid*: and do not *yield* to the greateſt *external Force.* This ſecures their *Figure* againſt any *Alteration*: and the *Intervalls* of the *Corpuſcles* muſt be always alike. By the *latter* 'twill be ever diſpoſed to *receive Matter* into it: and by the *former*, when once *received*, to *bear* it on along with it. *Water* is further capacitated to be a *Vehicle* to this *Matter*, by the *tenuity* and *fineneſs* of the *Corpuſcles* of which it *conſiſts.* We hardly know any *Fluid* in all *Nature*, except *Fire*, whoſe *conſtituent Parts* are ſo exceeding *ſubtil* and *ſmall* as thoſe of *Water* are. They'll paſs *Pores* and *Interſtices* that neither *Air* nor any other *Fluid* will. This enables them to enter the *fineſt Tubes* and *Veſſels* of *Plants*, and to introduce the *terreſtrial Matter*, conveying it to *all Parts* of *them*; whilſt each, by means of *Organs* 'tis endowed with for the purpoſe, *intercepts* and *aſſumes* into it ſelf ſuch *Particles* as are ſuitable to its own *Nature*, letting the *reſt paſs* on through the *common Ducts.* Nay we have almoſt every where *Mechanical Inſtances* of much the *ſame Tenor.* 'Tis obvious to every one how *eaſily* and *ſuddenly Humidity*, or the Corpuſcles of *Water* ſuſtained in the *Air*, pervade and *inſinuate* themſelves into *Cords*, however tightly twiſted: into *Leather*, *Parchment*, *Vegetable Bodies*, *Wood*, and the like. This it is that fits them for *Hygrometers*: and to *meaſure* and determine the different *quantities* of *Moiſture* in the *Air*, in different *Places* and *Seaſons*. How freely Water *paſſes* and carries with it *terreſtrial Matter*, through *Filtres*, *Colatures*, *Deſtillations*, &c. hath been intimated already.

8. *Water is not capable of performing this Office to Plants, unleſs aſſiſted by a due Quantity of Heat: and this muſt concurr or Vegetation will not ſucceed.* The *Plants* that were ſet in the Glaſſes Q. R. S. &c. in *October* and the following *colder Months*, had not near the *quantity* of *Water* ſent up into them, or ſo great an additional Encreaſe by much as *thoſe* that were ſet *in June*, *July*, and the *hotter*. 'Tis plain *Water* has no power of *moving* it ſelf: or riſing to the vaſt height it does in the more *tall* and *lofty Plants*. So far from this, that it does not appear from any *Diſcovery* yet made, that even its own *Fluidity* conſiſts in the *inteſtine Motion* of its *Parts*; whatever ſome otherwiſe very *Learned* and *Knowing Perſons* may have thought. There's no need of any thing more, for *ſolving* all the *Phænomena* of *Fluidity*, than ſuch a *Figure* and *Diſpoſition* of the *Parts*, as *Water* has. *Corpuſcles* of that *make*, and that are all *abſolutely Spherical*, muſt ſtand ſo very *tickle* and *nicely* upon each other, as to be ſuſceptible of every *impreſſion*: and, tho' not perpetually in *Motion* yet muſt be ever *ready* and *liable* to be *put* into it, by any the *ſlighteſt Force* imaginable. It is true, the *Parts* of *Fire* or *Heat* are not capable of *moving themſelves* any more than thoſe of *Water*: but they are more ſubtil, light, and *active*, than *thoſe* are, and ſo more *eaſily* put into *Motion*. In fine, 'tis evident and matter of Fact that *Heat* does operate upon and move the *Water*, in order to its carrying on the *Work* of *Vegetation*: but *how* 'tis agitated *it ſelf*,

ſelf, and *where* the *Motion* firſt *begins*, this is no fit *Place* to enquire.

That the Concourſe of *Heat* in this *Work* is really *neceſſary*, appears, not only from the *Experiments* before us, but from *all Nature*: From our *Fields* and *Foreſts*, our *Gardens* and our *Orchyards*. We ſee in *Autumn*, as the *Suns Power* grows gradually *leſs* and *leſs*, ſo its *effects* on *Plants* is *remitted*, and their *Vegetation ſlackens* by little and little. Its *Failure* is firſt diſcernible in Trees. Theſe are *raiſed* higheſt above the *Earth*: and require a more *intenſe Heat* to *elevate* the *Water*, charged with their *Nouriſhment*, to the *Tops* and *Extremities* of them. So that for want of *freſh ſupport* and *Nutriment* they ſhed their *Leaves*, unleſs ſecured by a very *firm* and *hardy Conſtitution* indeed, as our *ever-Greens* are. Next the *Shrubs* part with theirs: and then the *Herbs* and *lower Tribes*; the *Heat* being at length not ſufficient to ſupply even *theſe*, tho' ſo *near* the *Earth* the *Fund* of their *Nouriſhment*. As the *Heat* returns the ſucceeding *Spring*, *they* all recruit again: and are furniſh'd with *freſh ſupplies* and *verdure*. But firſt thoſe which are *loweſt* and *neareſt* the *Earth*, *Herbs*, and they that require a *leſſer degree* of *Heat* to raiſe the Water with its *Earthy Charge* into them. Then the *Shrubs* and *higher Vegetables* in their turns: and laſtly the *Trees*. As the Heat encreaſes, it grows *too powerful*, and hurries the Matter with too great *rapidity* thorow the *finer* and more *tender Plants*. *Theſe* therefore *go off*, and decay: and others that are more *hardy* and *vigorous*, and require a greater *ſhare* of *Heat*, ſucceed in their *Order*. By which Mechaniſm *provident Nature* furniſhes us with a very various and differiug *Entertainment*: and what is *beſt ſuited* to *each Seaſon*, all the *Year* round.

As the *Heat* of the *ſeveral Seaſons* affords us a *different Face* of *Things*; ſo the *ſeveral* diſtant *Climates* ſhew *different Scenes* of Nature, and *Productions* of the *Earth* *. The *Hotter Countries* yield ordinarily the *largeſt* and *talleſt Trees* : and thoſe too in much greater *variety* than the *colder* ever do. Even thoſe *Plants* which are *common to both*, attain to a much *greater Bulk* in the *Southern* than in the *Northern Climes*. Nay there are ſome *Regions* ſo *bleak* and *chill*, that they raiſe no Vegetables at all to any *conſiderable ſize*. This we learn from *Groenland*, from *Iſland*, and other Places of like *cold Site* and *Condition*. In theſe no *Tree* ever appears: and the very *Shrubs* they afford are *few*, *little*, and *low*.

* *Conf. Nat. Hiſt. Earth.* Pag. 267. & ſeq.

Again, in the *warmer Climates*, and ſuch as do furniſh forth *Trees* and the *larger Vegetables*, if there happen a *remiſſion* or *diminution* of the *uſual heat*, their *Productions* will be *impeded* and *diminiſhed* in Proportion. Our *late Colder Summers* have given us Proof enough of this. For tho' the *Heat* we have had was ſufficient to raiſe the *Vegetative Matter* into the *lower* Plants, into our *Corns*, our Wheat, Barley, Peaſe and the like: and we have had plenty of Strawberries, Rasberries, Currans, Goosberries, and the *Fruits* of ſuch other Vegetables as are *low* and *near* the *Earth* : Yea and a moderate ſtore of Cherries, Mulberries, Plums, Filberts, and ſome others that grow at a ſomewhat greater *Height*; yet our Apples, our Pears, Walnuts, and the Productions of the *taller* † *Trees* have been *fewer*, and thoſe not ſo *kindly*, ſo thorowly *ripen'd* and brought to that *Perfection* they were in the former more benign and *warm Seaſons*. Nay even the lower *Fruits* and *Grains* have had ſome ſhare in the Common Calamity: and fallen ſhort both in *Number* and *Goodneſs* of what the *hotter* and kinder *Seaſons* were wont to ſhew us. As to our Grapes, Abricots, Peaches, Nectarins, and Figs, being tranſplanted hither out of *hotter Climes*, 'tis the leſs wonder we have *of late* had ſo general a *Failure* of them.

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† The *Dwarf* Apple and Pear-Trees have *ſucceeded* better. And indeed in Trees of the *ſame Kind*, thoſe that keep *cloſeſt* to the *Earth* always produce the *moſt* and *beſt* Fruit. For which Reaſon 'tis that the Gardiners *check* and *reſtrain* the *Growth* of their better Fruit-Trees: and prevent their *running up* to too great a *Height*.

Nor is it the *Sun*, or the ordinary emiſſion of the *Subterranean heat* only, that promotes Vegetation: but *any other* indifferently, according to its *Power* and *Degree*. This we are taught by our *Stoves*, *Hot Beds*, and the like. All *Heat* is of like *kind*: and where-ever is the ſame *Cauſe*, there will be conſtantly the ſame *Effect*. There's a *Procedure* in every *Part* of *Nature*, that is perfectly *regular* and *geometrical*, if we can but find it out: and the further our *Searches* carry us, the *more* ſhall we have Occaſion to *admire* this, and the better 'twill *compenſate* our *Induſtry*.
